Recreational Vehicle Refueling Systems Test Strategy & Protocol

Reactive Organic Gas (ROG) emissions from RV refueling system = breathing loss + working loss

Breathing loss = vented emissions from the fuel tank during storage + permeation from the fillneck hose during storage + permeation from the fuel hose during storage (Fig. 1)

Working loss = displaced vapor from the receiving tank during refueling + dripping loss from the nozzle when stop the refueling (Fig. 2)

Permeation from the fillneck cap might be ignored if the cap is non-vented and made of low permeation plastic materials.

Vented emissions from the nozzle might be ignored if it is a non-dripping nozzle (sealed well).

Vented emissions from the pump might be ignored if it is a sealed steel pump.

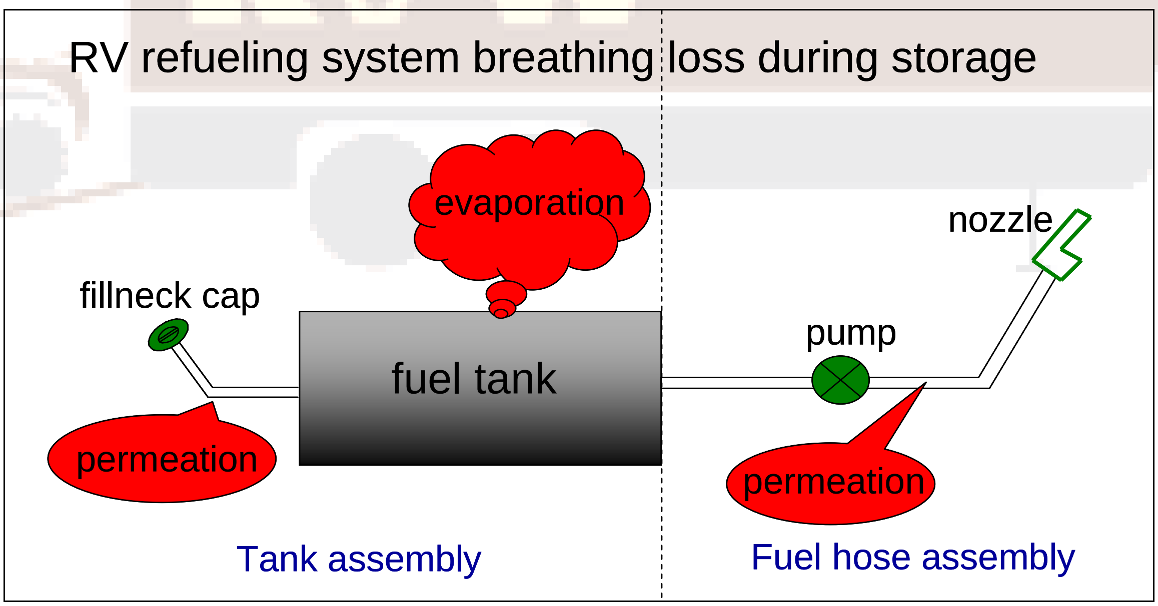

Figure 1. Schematic illustration of RV refueling system breathing loss during the storage.

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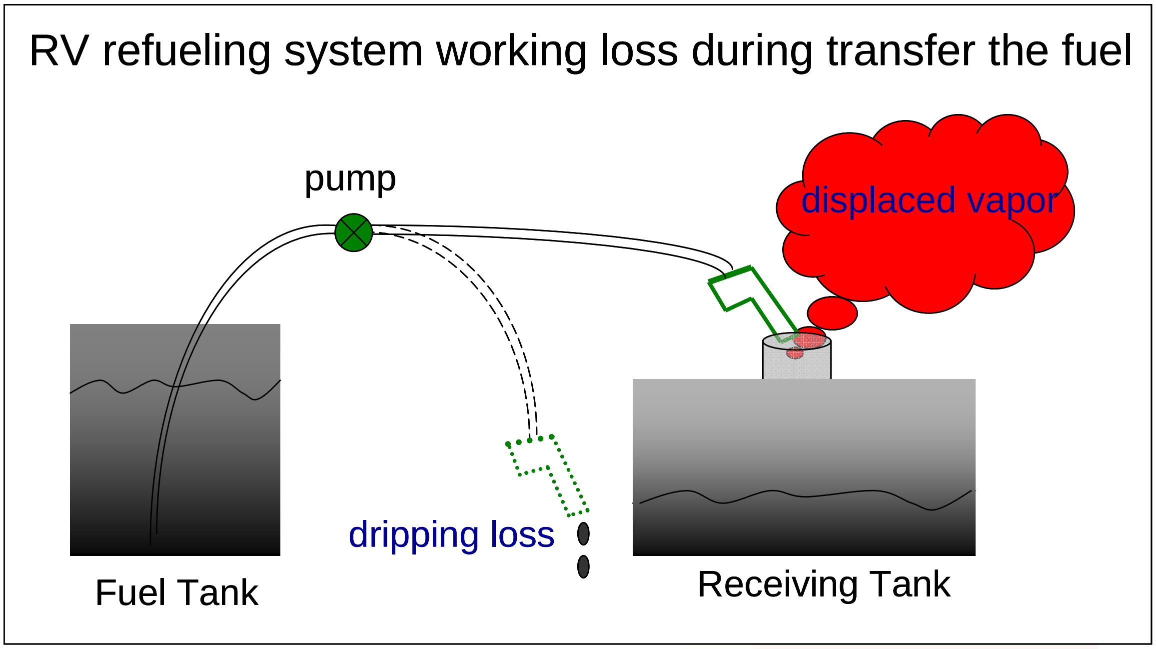

Figure 2. Schematic illustration of RV refueling system working loss during the refueling.

RV refueling system breathing loss Sealed House Emissions Detection (SHED) test procedure

Apply to test the refueling system as one unit

Pre-Soak Test:

Emissions from <u>tank assembly + dried-wall empty hose assembly</u>.

1. Apply to the new refueling system.
2. Fill the refueling tank to 50% capacity with California Phase 3 Reformulated Gasoline (CaRFG3) summer fuel containing ethanol 6% in volume (E6).
3. Condition the refueling tank for 6 hours at 65ºF.
4. Conduct a one day diurnal SHED test at 65ºF-105ºF-65ºF.
5. Repeat steps 2-4 three times.

Post-Soak Test:

Emissions from <u>tank assembly + wetted-wall empty hose assembly</u>

1. Drain and refuel the tank to 50% capacity with fresh CaRFG3 summer fuel E6.
2. Recirculate the fuel through the fuel filler hose back into the fuel tank for 1 minute.
3. Lay the filler nozzle on the refueling tank frame below the fuel tank level.
4. Soak the refueling system for 30 days at 30° C $\pm$ 10° C to condition the fuel hose.

5. Drain the refueling system. Refuel the tank to 50% capacity with CaRFG3 summer fuel E6. Do not circulate the fuel to the hose. Lay the filler nozzle on the refueling tank frame.
6. Condition the refueling system for 6 hours at 65 °F.
7. Conduct diurnal SHED test at 65ºF-105ºF-65°F.
8. Repeat the step 5-7 three times.

Emissions from <u>tank assembly + fully filled hose assembly.</u>

1. Drain and refuel the tank to 50% capacity with fresh CaRFG3 summer fuel E6.
2. Recirculate the fuel through the fuel filler hose back into the fuel tank for 1 minute. Lay the filler nozzle on the refueling tank frame below the fuel tank level.
3. Condition the refueling tank system for 6 hours at 65ºF.
4. Conduct a one day Diurnal SHED Test at 65ºF-105ºF-65ºF
5. Repeat steps 1-4 three times.

Controlled vented emissions from <u>tank assembly + fully filled hose assembly</u> using canister

1. Drain and refuel the tank to 50% capacity with CaRFG3 summer fuel E6.
2. Recirculate the fuel through the fuel hose back into the fuel tank for 1 min. Lay the filler nozzle on the refueling tank frame below the fuel tank level.
3. Purge the carbon canister with 300 bed volumes of dry air through the canister at the canister manufacturer’s recommended purge rate.
4. Condition the refueling tank system for 6 hours at 65 ºF.
5. Connect the rollover valve to the canister.
6. Conduct a seven-day diurnal SHED test at 65ºF-105ºF-65ºF.
7. Weight the canister before and after 7 day diurnal SHED test.

Apply to test the refueling system part by part

Emissions from <u>the tank assembly (tank+fillneck hose+fillneck cap) only</u>

1. Seal the tank with low permeation plug at fuel hose connection spot.
2. Refuel the tank to 50% capacity with CaRFG3 summer fuel E6. If the tank is metal, continue with step 3. If the tank is plastic, soak the tank for 30 days at 30±10 °C to condition the tank.
3. Drain and refuel the tank to 50% capacity with CaRFG3 summer fuel E6.
4. Condition the tank assembly for 6 hours at 65 ºF.
5. Conduct a one day diurnal SHED test at 65ºF-105ºF-65ºF.
6. Repeat step 3-5 three times.

Permeations from <u>the hose assembly (pre-hose+pump+post-hose+nozzle)</u>

1. Soak the hose assembly at ambient temperature for 30 days if the hose is not low permeation hose; for 140 days if the hose is low permeation hose: Fill the hose assembly with CaRFG3 summer fuel E6 to 100% capacity and place the hose on the floor.
2. Drain the hose assembly. Continue with step 4 if the reverse pump system is applied.
3. Refill the hose assembly to 100% capacity with CaRFG3 summer fuel E6.
4. Place the hose assembly on the floor, leaving the pre-hose as the way it is, and post-hose curved 2 circles.
5. Condition the hose assembly for 6 hours at 65 °F.
6. Conduct a one day diurnal SHED test at 65-105-65 °F.
7. Repeat step 2-6 three times.

Displaced vapor measurement:

1. Deriving the formula to estimate refueling losses

To derive the formula for the mass of gasoline that will be displaced from the receiving tank when refueling from the fuel tank, the general vapor density formula[1] is used:

Wv = MvPv /RT

Where:

Wv = vapor density, lb/ft3

Mv = vapor molecular weight, lb/lb-mole;

Note: vapor molecular weight is related to RVP; so for gasoline with RVP 7 to 8.3, the molecular weight is 68 (AP-42, Table 7.1-3).

R = the ideal gas constant, 10.731 psia ft^3/lb-mole deg R

Pv = vapor pressure at daily average temperature, psia

T = daily average temperature, deg R

Note: this is absolute temperature in degrees Rankine (R), not Fahrenheit: to convert to deg R from deg F, add 459.69.

Since density (Wv) = m /V , m = VvMvPv /RT

Where:

m= mass of gasoline displaced as vapor (lb)

Vv = volume of gasoline displaced as vapor (ft3)

2. Calculating an estimated emission factor for displaced vapor:

Assumptions:

The volume of gasoline vapor displaced is equal to the volume of gasoline pumped out of the fuel tank into the receiving tank.

Gasoline RVP = 7

Vapor molecular weight = 68, at 60 deg. F. (see note above).

Conversions:[2]

1 gal gasoline =0.13 ft^3

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[1] From AP-42, page 7.1-64, and other references consulted
[2] Reference website: http://www.onlineconversion.com/volume.htm

T = 60 deg F = 519.69 deg R (absolute temp.)

1 lb = 453.59 grams

Plugging the values into above formula gives:

Mass of gasoline lost as vapor = VvMvPv /RT= 0.13 x 68 x 3.5 /10.731 x 519.69 = 0.005548 (lbs) = 2.52 grams

Therefore 1 galon of gasoline pumped into a receiving tank results in 2.52 grams of gasoline lost as displaced vapor.

Emission factor for refueling losses (displaced vapor losses) = 2.52 gram/gal vapor (gasoline RVP 7, at 60 deg F).

Dripping loss measurement:

Dripping loss from the nozzle depends on the users how to terminate the refueling process. From ARB staff, about 1 ml gasoline drops from the nozzle when holding the nozzle in the fillneck of the receiving tank for a few seconds after refueling; about 30 ml liquid gasoline drops from the nozzle when pulling the nozzle out of the fillneck immediately after the refueling. With the volume of 1-30ml gasoline, ARB staff calculates the mass of the dripping loss: [3]

Mass of 1 ml GaRFG summer fuel E6: 0.71 grams

Mass of 30 ml GaRFG summer fuel E6: 21.8 grams

[3] Gasoline RVP 7: vapor molecular weight at 60 F M_V=68 lb/mole, Liquid density at 60 F W_L=5.6 lb/gal